PATENT ABSTRACTS OF JAPAN

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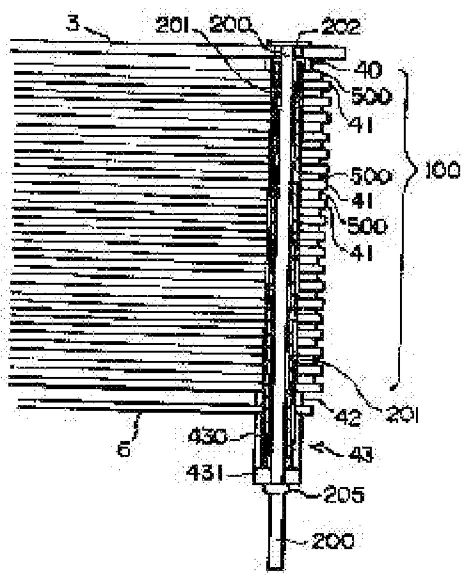
(54) PHOTOMULTIPLIER TUBE



(57)Abstract:
PROBLEM TO BE SOLVED: To significantly reduce the possibilities that multiplication rates are varied and that fine-mesh dynodes are broken during manufacture.
SOLUTION: This photomultiplier tube has a caulked part 205 formed at a predetermined position on a hollow pipe 2 which has a T-shaped edge 202 and which passes through a dynode part 500 including fine-mesh dynodes, thereby specifying the layered structure of a photomultiplier part by means of the edge 202 and the caulked part 205. The photomultiplier tube whose manufacturing errors are reduced by accurately controlling the intervals between the fine- mesh dynodes can thus be obtained. Also, the hollow pipe is a double structure of an inside pipe 200 made of a conducting material and an outside pipe 201 made of an insulating material, the inside pipe 200 constituting a part of a wiring structure electrically connecting a photocathode to a stem pin.

CLAIMS

[Claim(s)]
[Claim 1]A photo-multiplier comprising:
Photo cathode for emitting a photoelectron corresponding to light which entered.
Fine mesh dynode which has 1000 or more lines even if small [where prescribed interval alienation is mutually carried out via an insulator, it laminates, and] per inch.
An electron multiplier for carrying out cascade multiplication of the photoelectron which has two or more steps of dynode parts provided with the upper part and a lower electrode which grasp this fine mesh dynode where predetermined tension is applied, respectively, and was emitted from said photo cathode.
An anode for collecting secondary electrons emitted from said electron multiplier, A pipe for specifying a position of a laminating direction of each of this dynode part, where it comprised an outside pipe which consists of insulating materials, and an inner pipe which penetrate this outside pipe and which consists of conductive materials and each of said dynode part is penetrated at least.

[Claim 2]The photo-multiplier according to claim 1, wherein said outside pipe is shorter than said inner pipe.
[Claim 3]The photo-multiplier according to claim 1 or 2, wherein said inner pipe has an edge part of a larger diameter than an opening diameter of said outside pipe at the 1st end.
[Claim 4]A photo-multiplier of claim 1-3 provided with a well-closed container which is held after two or more lead pins for impressing prescribed voltage have penetrated the pars basilaris ossis occipitalis, and stores said photo cathode, said electron multiplier, and said anode at least given in any 1 paragraph.
[Claim 5]The photo-multiplier according to claim 4 having a conductive ring set as this photo cathode and same electric potential while having an opening for making a photoelectron which was provided between said photo cathode and an electron multiplier, and was emitted from this photo cathode penetrate.
[Claim 6]it being fixed to said electron multiplier via an insulator by said pipe, and said conductive ring, The photo-multiplier according to claim 5 provided with a spring electrode which contacts a wall of this well-closed container installed [want / to make it] in a prescribed position of this well-closed container where prescribed distance alienation of said electron multiplier is carried out from a wall of said well-closed container.
[Claim 7]Said conductive ring is provided with a contact electrode for electrically connecting with said photo cathode, and and said 1st end of said inner pipe, The photo-multiplier according to claim 4 or 5, wherein it is electrically connected with said conductive ring and the 2nd end of said inner pipe is electrically connected with one of lead pins among lead pins currently held with said well-closed container.
[Claim 8]A photo-multiplier comprising of claim 4-7 given in any 1 paragraph:
Each dynode part of said electron multiplier.
Two or more relay lead pins for specifying an interval of fine mesh dynode of the 1st step of this electron multiplier, and said photo cathode, while electrically connecting a lead focus supported at the pars basilaris ossis occipitalis of said corresponding well-closed container.

[Claim 9]A photo-multiplier of claim 1-8 comprising the 2nd insulator characterized by

comprising the following given in any 1 paragraph.
The 1st insulator that is provided with an insulator which contacted this anode from the field side where the field side which faced said electron multiplier of said anode is opposite, and has a breakthrough of a path with this larger insulator than an outer diameter of said outside pipe.
A breakthrough of a larger and path smaller than an inside diameter of this outside pipe than an outer diameter of said inner pipe.

[Claim 10]A photo-multiplier of claim 1-9, wherein the number of lines which constitute said fine mesh dynode is 1500 or more [per inch] and the line width is 2.4 micrometers - 6 micrometers given in any 1 paragraph.
[Claim 11]A photo-multiplier of claim 1-10 given in any 1 paragraph with which said fine mesh dynode is characterized by the line width's being 2.4 micrometers - 6 micrometers, and having a void of 45% - 65%.
[Claim 12]The photo-multiplier according to claim 11, wherein the line width is 2.4 micrometers - 6 micrometers and said fine mesh dynode has a void of 45% - 50%.
[Claim 13]An interval from said photo cathode to a dynode part which has countered this photo cathode and directly among said dynode parts, A photo-multiplier of claim 1-12, wherein it is 2.0 mm - 5.0 mm and intervals between fine mesh dynodes of said adjoining dynode part are 0.4 mm - 1.6 mm given in any 1 paragraph.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the feed voltage structure for setting the prefabricated frame structure for laminating each dynode part which has fine mesh dynode especially about the photo-multiplier in which photon detection is possible in a high magnetic field for every prescribed interval, and photo cathode as prescribed potential.
[0002]
[Description of the Prior Art]Conventionally, as a photo-multiplier in which photon detection is possible in a high magnetic field, what was indicated by JP,51-43068,A and JP,59-221960,A is known, for example. The structure where two or more mesh dynodes have the electron multiplier laminated via the insulator in these gazettes is indicated.
[0003]The structure of fine mesh dynode applicable to the photo-multiplier indicated by each above-mentioned gazette, For example, G.Barbiellini, A.Martinis, F.Scuri,"A simulation study of the behaviour of fime mesh photomultipliers",Nuclear. It is indicated by Instruments and Methods in Physics Research A362 (15 August, 1995) and p.245-252.
[0004]
[Problem(s) to be Solved by the Invention]Generally the photo-multiplier which can operate also in a magnetic field, The electron orbit of the secondary electron emitted from this fine mesh dynode is provided with the structure of being hard to be influenced by an external magnetic field, by using fine mesh dynode with the detailed line width, and narrowing the installation interval of this fine mesh dynode. The interval of photo cathode and the fine mesh dynode of the 1st step is restricted to the range of 2.0 mm - 5.0

mm, and, specifically, the interval between these adjoining fine mesh dynodes is restricted to 0.4 mm - 1.6 mm. The above-mentioned fine mesh dynode, Even if there are few the lines per inch, the mesh dynode which is 1000 or more is said, and as fine mesh dynode actually manufactured, what has a line per [1500-2000] inch is in use now. In this specification, these fine mesh dynode is distinguished with the notation of #1500 and #2000.
[0005]However, it is difficult to bend, since the line width of the fine mesh dynode of #1500 and #2000 is as detailed as about 5 micrometers, and to constitute a laminated structure only from this fine mesh dynode, for example. So, in the example concerning this invention, as shown in drawing 22, for example, By grasping, where predetermined tension is applied, the edge part of this fine mesh dynode with the upper electrode and lower electrode of disk form which have an opening for exposing this fine mesh dynode in the center, The structure of preventing the deflection of this fine mesh dynode 50 is adopted. As a structural feature of the obtained dynode part, while the above upper part and a lower electrode have sufficient intensity to the power in which it is added from a circumferencial direction, respectively, Changing easily to the power (power in which it is added from the field by the side of the photo cathode of fine mesh dynode and/or the field by the side of an anode) in which it is added, from the laminating direction (it is in agreement with the incidence direction of light) of this dynode part can understand easily. For example, in the assembly process of an electron multiplier tube, if the applied power (power from a laminating direction) is unevenly added to each dynode part, it will become difficult to originate in torsion etc. which were produced in the above-mentioned electrode, and to control correctly the interval between each adjoining fine mesh dynode. In particular, in such a case, a multiplication factor (the number of the photoelectrons generated in several/photoelectric surface of the secondary electron which reaches an anode) has a technical problem of variation arising and the fine mesh dynode itself being torn.
[0006]Since the mesh electrode for vidicons was conventionally diverted to some other purpose when the photo-multiplier concerned was manufactured, the manufacturing conditions (for example, a void, line width, etc.) of the fine mesh dynode optimal as the photo-multiplier concerned were not known actually.
[0007]While it is made in order that this invention may solve the above technical problems, and suggesting the manufacturing conditions of the optimal fine mesh dynode for the photo-multiplier concerned from the viewpoint of a multiplication factor, and a manufacturing viewpoint, By laminating without changing dynode part ******* which has fine mesh dynode in the assembly process of an electron multiplier, It aims at providing the photo-multiplier provided with the feed voltage structure for setting photo cathode as prescribed potential where the prefabricated frame structure which can control the interval of adjoining fine mesh dynode correctly, and this prefabricated frame structure were used in which photon detection is possible also in a high magnetic field.
[0008]
[Means for Solving the Problem]A photo-multiplier concerning this invention is provided with the following.
Photo cathode for being a photo-multiplier in which photon detection is possible also in a high magnetic field, as mentioned above, and emitting a photoelectron corresponding to light which entered at least.

An electron multiplier for carrying out cascade multiplication of the photoelectron emitted from this photo cathode.
An anode for collecting secondary electrons emitted from this electron multiplier installed in a position which carried out prescribed distance alienation with this electron multiplier via an insulator.
These photo cathode, an electron multiplier, and an anode are stored in a well-closed container constituted by housing in which an aluminum film was formed in the wall, and stem which supports a conductive lead pin (stem pin) for setting each of each dynode part as prescribed potential.
[0009]The above-mentioned electron multiplier laminates two or more dynode parts by which prescribed interval alienation was mutually carried out via an insulator of ring form which has the breakthrough prolonged along an incidence direction of light, and is constituted. Especially each dynode part is provided with the following.
The above-mentioned fine mesh dynode.
An upper electrode which has the breakthrough prolonged along an opening for exposing a field by the side of photo cathode of this fine mesh dynode, and an incidence direction of light.
A lower electrode which puts and holds an edge part of this fine mesh dynode with this upper electrode while having the breakthrough prolonged along an opening for exposing a field by the side of an anode of this fine mesh dynode, and an incidence direction of light.
The above-mentioned upper electrode is provided with a height for electrically connecting a dynode part and one to which it corresponds of the lead pins currently supported by the above-mentioned stem via a relay lead pin.
[0010]In a photo-multiplier concerning this invention, via an insulator, the above-mentioned anode and the above-mentioned dynode part at least are laminated so that each breakthrough may make it in agreement along an incidence direction of light.
[0011]A photo-multiplier concerning this invention is provided with a pipe which penetrated space defined by breakthrough of each member laminated as mentioned above along an incidence direction of light. Especially this pipe contains an outside pipe which consists of insulating materials (for example, alumina), and an inner pipe which consists of a conductive material (for example, stainless steel) which penetrated this outside pipe. And an inner pipe has an edge part of a larger diameter than an opening diameter of an outside pipe at the 1st end. The length of this inner pipe is designed become longer than the length of an outside pipe.
[0012]By forming a caulking part in a prescribed position of an inner pipe mentioned above where a breakthrough of each above-mentioned member is penetrated, T type-like an edge part and this caulking part of the above-mentioned inner pipe specify a laminated structure of the above-mentioned electron multiplier. The above-mentioned caulking part is formed by applying power to the above-mentioned inner pipe perpendicularly to a laminating direction of each dynode part. This inner pipe is hollow. Therefore, there is little power applied to this inner pipe, and it ends, and power which is made to transform each dynode part can realize a prefabricated frame structure which is not added in an assembly process of the above-mentioned electron multiplier.
[0013]A photo-multiplier concerning this invention is formed between photo cathode and an electron multiplier, and is provided with a conductive ring which has an opening for

passing a photoelectron emitted from this photo cathode. This conductive ring is provided with a contact electrode for making a breakthrough prolonged along an incidence direction of light, and this conductive ring and photo cathode set it as same electric potential. And an edge part of the above-mentioned inner pipe is carrying out direct contact to this conductive ring, where a breakthrough is penetrated. This is for setting photo cathode as prescribed potential by electrically connecting an end of this inner pipe, and a predetermined lead pin of a stem via a relay lead pin. Therefore, this inner pipe is functioning also as a lead pin for feed voltages for setting photo cathode as prescribed potential while functioning as specifying a laminated structure of an electron multiplier. And feed voltage structure for setting photo cathode as prescribed potential is realized by a conductive ring and an inner pipe which have the contact electrode mentioned above, a relay lead pin, and lead pin (stem pin) supported by stem.
[0014]The above-mentioned conductive ring is provided with a spring electrode for making an electron multiplier install in a prescribed position of this well-closed container further, where prescribed distance alienation is carried out from a wall of a well-closed container. Therefore, it is horizontally prescribed by spring electrode of this conductive ring to an incidence direction of light, and, as for a position in a well-closed container of the electron multiplier concerned, is perpendicularly prescribed by relay lead pin.
[0015]The above-mentioned conductive ring is being fixed to this electron multiplier tube by the above-mentioned pipe which penetrated a breakthrough of this conductive ring, where prescribed distance alienation is carried out from an electron multiplier via an insulator. This insulator had the breakthrough prolonged along an incidence direction of light, and a pipe has penetrated it to this breakthrough. After the above-mentioned anode has also carried out prescribed distance alienation from an electron multiplier via an insulator which has a breakthrough, it is being fixed to this electron multiplier by this pipe.
[0016]A photo-multiplier concerning this invention is the insulator contacted by field by the side of a stem of an anode, and is further provided with an insulator only for prescribed distance to make the 1st end (end in which an edge part was provided) of the above-mentioned pipe (inner pipe), the 2nd end located in an opposite hand, and this anode estrange. This insulator comprises the 1st insulator that has a breakthrough of a larger path than an outer diameter of the above-mentioned outside pipe, and the 2nd insulator that has a breakthrough of a larger path than an outer diameter of an inner pipe smaller than an inside diameter of this outside pipe.
[0017]The above-mentioned outside pipe is shorter than the above-mentioned inner pipe. This is for storing the whole outside pipe to space defined at least by a breakthrough of a conductive ring, a breakthrough of a dynode part, a breakthrough of an anode, and breakthrough of each insulator in which it was provided between these each member. And an inner pipe penetrates the above-mentioned space and has sufficient length for the both ends to be exposed from this space. By this composition, an outside pipe (insulating material) functions as maintaining an insulating state of each dynode part and an inner pipe (conductive material), and this inner pipe functions also as some internal wiring of the photo-multiplier concerned.
[0018]Next, artificers examined a void of fine mesh dynode which is adapted for this photo-multiplier in order to control a multiplication factor (the number of photoelectrons generated in several/photoelectric surface of a secondary electron which reaches an

anode) of a photo-multiplier concerning this invention the optimal. As a result, the line width was 2.4 micrometers - 6 micrometers, and it discovered that 45% - 65% were the optimal.
[0019]Here, line width is set as 6 micrometers or less because it is necessary to avoid that originate in **** (the maximum turning radius) of an electron in a magnetic field, and a multiplication factor of the photo-multiplier concerned falls. Line width is set as not less than 4 micrometers because the fine mesh dynode itself needs to have the intensity which can be borne enough in tension applied during manufacture.
[0020]45% - 50% of a void of a manufacturing viewpoint to the above-mentioned fine mesh dynode is desirable. For example, it is because a danger of being torn while this fine mesh dynode manufactures will increase if a void exceeds 50% even if line width is not less than 2.4 micrometers. In this specification, the void S (%) of fine mesh dynode is defined by $S(\%) =\{(b-a)^2/b^2\} \times 100$, when line width is set to a and it sets a line pitch to b (refer to drawing 12 and drawing 13).
[0021]
[Embodiment of the Invention]Hereafter, one example of the photo-multiplier concerning this invention is described using drawing 1 - drawing 29. Identical codes are given to the identical parts in a figure, and explanation is omitted.
[0022]Drawing 1 is a figure showing the assembly process of the whole photo-multiplier concerning this invention. The housing 1 of the cylindrical shape with which, as for the photo-multiplier concerned, the aluminum film 1a which is an electrode for feed voltages to photo cathode was formed in that wall in this figure, It has the well-closed container constituted by the stem 8 currently supported in the state where the lead pin (stem pin) 9 for supplying the voltage supplied from the external bleed-screw circuit (refer to drawing 9) to desired dynode etc. was made to penetrate. The filling pipe 10 of the hollow for pouring in the metallic fumes for photo cathode formation after an assembly is formed in the pars basilaris ossis occipitalis of the above-mentioned stem 8.
[0023]The electron multiplier 100 stored in the well-closed container mentioned above, The conductive ring 3 which functions on the 1st step dynode part side as a converging electrode via the insulator (ceramic spacer) 40 which has a breakthrough is fixed, and the anode 6 is fixed via the insulator (ceramic spacer) 42 which has a breakthrough also in the final stage dynode part side. This electron multiplier 100 is in the state supported with the relay lead pin 7 which supplies prescribed voltage, respectively, and is set as the prescribed position in a well-closed container to the incidence direction L of light. That is, the relay lead pin 7 functions as specifying the interval of photo cathode and the 1st step dynode part 500 (especially fine mesh dynode 50) of this electron multiplier while functioning as wiring for supplying prescribed voltage. It has the breakthrough to which the above-mentioned conductive ring 3 and the anode 6 extended along the incidence direction L of light.
[0024]The above-mentioned electron multiplier 100 is constituted by laminating two or more dynode parts 500 one by one via the ring shape insulator (ceramic ring spacer) 41. the case where 16 steps of dynode parts 500 are laminated in this specification, for example -- from the dynode part of the 1st step up to the dynode part of a final stage (16 steps) -- order -- DY1, DY2, and ... it is written as DY15 and DY16 (refer to drawing 9).
[0025]Especially the above-mentioned dynode part 500, for example #1500 and the fine mesh dynode 50 with a line width of 5.5 micrometers - 5.6 micrometers, It comprises the

upper electrode 51 and the lower electrode 52 of ring shape which grasp the edge part of this fine mesh dynode 50 where predetermined tension is applied to this fine mesh dynode 50. These each ring like electrodes 51 and 52 have the breakthrough prolonged along the opening for passing the photoelectron from photo cathode, or the secondary electron from the fine mesh dynode 50 of the preceding paragraph, and the incidence direction L of light, respectively.
[0026]These conductive rings 3, the insulators 40, 41, and 42, each dynode part 500, and the anode 6, Where each breakthrough is coincided with the laminating direction (the incidence direction L of light, and coincidence) of the fine mesh dynode 50, it is unified by the pipe 2, and the laminated structure of the electron multiplier 100 is constituted. At this time, the insulator 43 which this pipe 2 penetrated is formed in the stem 8 side of the anode 6, and contact with this anode 6 and the pipe 2 is prevented.
[0027]The main part of the photo-multiplier shown in drawing 2 by the above assembly process is obtained.
[0028]Then, where the inside of the housing 1 and the well-closed container constituted by the stem 8 is made into a vacuum, the metallic fumes for photo cathode formation are poured in via the filling pipe 10, and the photo cathode 11 is formed in the wall of the light incidence part 1b of the housing 1. The wall of the light incidence part 1b can be made to vapor-deposit selectively (a temperature gradient with other portions is produced), and the above-mentioned metal by suppressing low the temperature of this light incidence part 1b, heating the whole well-closed container at this time. Then, as shown in drawing 3, the inside of a well-closed container is held to a vacua by heating and closing the breakthrough 10a of this filling pipe 10. In the inside 10b of a figure, a part of pipe 10 by which heating sealing was carried out is shown.
[0029]Next, the structure of the pipe 2 for realizing the prefabricated frame structure of the electron multiplier 100 and the laminated structure of each dynode part 500 is explained using drawing 4 - drawing 8.
[0030]The electron multiplier 100 is laminated via the ring shape insulator 41 in the dynode part 500. Ahead [of this electron multiplier 100] (side into which the photoelectron from the photo cathode 11 enters), the conductive ring 3 is fixed via the insulator 40, and the anode 6 is being fixed to that back (side to which the secondary electron from final stage dynode part DY16 is emitted) via the insulator 42. The insulator (ceramic spacer) 43 is also formed in the opposite hand of the insulator 42 via this anode 6.
[0031]These each member has the breakthrough prolonged along the incidence direction L of light, respectively, as mentioned above, and it is laminated so that this breakthrough may be in agreement with the laminating direction of fine mesh dynode. The pipe 2 into which the end was processed in the shape of a T character realizes the laminated structure of the electron multiplier 100 concerned by forming the caulking part 205 in the portion which exposed the space defined by these breakthroughs from the above-mentioned insulator 43 as it penetrated along the laminating direction and was shown in drawing 5. If it puts in another way, the position of the laminating direction of each above-mentioned member will be prescribed by this pipe 2. Drawing 5 is an enlarged drawing of the portion shown with the sign A among drawing 4.
[0032]As shown in drawing 5, the caulking part 205 applies power perpendicularly to the laminating direction of the fine mesh dynode 50, and since it is formed by crushing this pipe 2, it can realize the prefabricated frame structure to which power unnecessary to a

laminating direction is not added in this electron multiplier 100 in the ****** case. The insulator 43 comprises the two insulators 430 (the 1st insulator: ceramic spacer) and 431 (the 2nd insulator: ceramic spacer), and its diameter of the breakthrough of this insulator 431 is smaller than the diameter of the breakthrough of this insulator 430.

[0033]The above-mentioned pipe 2 comprises the inner pipe 200 in which an end consists of a conductive material which has the edge part 202 processed in the shape of a T character, and the outside pipe 201 which has the breakthrough 204 which this inner pipe 200 penetrates, as shown in drawing 6. With a natural thing, the diameter of the breakthrough 203 of the inner pipe 200 is smaller than the diameter of the breakthrough 204 of the outside pipe 201. This outside pipe 201 is shorter than the inner pipe 200 (refer to drawing 7).

[0034]Drawing 8 is an enlarged drawing of the portion shown with the sign B among drawing 4. As shown also in this figure, the outside pipe 201 is stored in the space defined by the breakthrough of each above-mentioned member (the conductive ring 3, the electron multiplier 100, the anode 6, the insulators 40, 41, 42, and 43). On the other hand, the inner pipe 200 is in the state which penetrated the breakthrough 204 of the outside pipe 201, it penetrated the inside of this space and the both ends have exposed it. Therefore, the position of the laminating direction of each above-mentioned member is prescribed by the edge part 202 and the caulking part 205 of T type of this inner pipe 200. Here, the insulator 431 mentioned above is functioning as making the outside pipe 201 store in above-mentioned space. For this reason, the diameter of the breakthrough of this insulator 431 is designed become smaller than the inside diameter of the outside pipe 201 more greatly than the outer diameter of the inner pipe 200. It is designed shorter than the inner pipe 200 so that storage of the whole also of the above-mentioned outside pipe 201 may be attained in above-mentioned space. And this outside pipe 201 functions as the inner pipe 200 and each dynode part 500 not contacting.

[0035]At the time of operation of the photo-multiplier concerned, from the bleed-screw circuit shown in drawing 9, predetermined voltage is impressed to the conductive ring 3, each fine mesh dynode 50 of each dynode parts DY1-DY16, and the anode 6, and it is set as desired potential, respectively. Namely, between the conductive ring 3 and 1st step dynode part DY1 and between dynode part DY_k and dynode part DY_{k+1} (... k= 1, 2, n-1 and n number of stages of a dynode part). The voltage of tens of v - hundreds of v is impressed via the relay lead pin 7 from the stem pin 9 held at the stem 8. Then, the potential of 1st step dynode part DY1 is higher than the potential of the conductive ring 3, and the potential of dynode part DY_{k+1} is higher than the potential of dynode part DY_k, and the potential of the anode 6 is higher than the potential of final stage dynode part DY_{16}, and it is set up.

[0036]The photo cathode 11 changes into a photoelectron the light which entered into the light incidence part 1b of the photo-multiplier concerned. When the photoelectron generated with the photo cathode 11 passes the opening 304 (Drawing . ten references) of the conductive ring 3, it converges, and it is accelerated to this 1st step dynode part DY1 side by the electric field formed between this conductive ring 3 and 1st step dynode part DY1. And if a part of this accelerated photoelectron collides with the fine mesh dynode 50 contained in this 1st step dynode part DY1, a secondary electron will be emitted from this fine mesh dynode. continuing -- this -- the photoelectron which passed through the pore of the fine mesh dynode 50 of the 1st step, and the emitted secondary electron, being

accelerated in the direction of dynode part DY2 of the next step according to the electric field currently added -- this -- a secondary electron is further emitted by the fine mesh dynode 50 contained in the dynode part of the 2nd step. Thus, multiplication of the secondary electron is carried out and it is emitted as a photoelectron and a secondary electron are led to 1st step dynode part DY1 to n-th step dynode part DY_n one by one. It is accelerated by the electric field between this final stage dynode part DY16 and the anode 6, and the secondary electron which passed through the pore of dynode part DY16 of a final stage reaches this anode 6. The actinometry of the light which reached the light incidence part 1b of the photo-multiplier concerned becomes possible by the number of the secondary electron which reached this anode 6, i.e., the current amount which flows into the anode 6.
[0037]Next, the detailed structure of the conductive ring 3 mentioned above is explained using drawing 10. As mentioned above, this conductive ring 3 is formed between the photo cathode 11 and the electron multiplier 100, and has the opening 304 for making the photoelectron emitted from this photo cathode 11 penetrate. This conductive ring 3 is provided with the contact electrode 301 for making into same electric potential the breakthrough 302 prolonged along the incidence direction L of light, and this conductive ring 3 and the photo cathode 11. And the edge part 202 of the inner pipe 200 carries out direct contact to this conductive ring 3, where the breakthrough 302 is penetrated. This is for giving predetermined potential to the photo cathode 11 by electrically connecting the end of this inner pipe 200, and the predetermined stem pin 9 via the relay lead pin 7, as shown in drawing 11. Therefore, this inner pipe 200 is functioning on the photo cathode 11 also as a lead pin for giving prescribed potential while functioning as specifying the laminated structure of the electron multiplier 100. The number 303a shows the welded section for connecting the contact electrode 301 and a ring body among drawing 10, and the number 303c shows the welded section for reinforcing the breakthrough 302. The number 250 shows the welded section of the inner pipe 200 and the relay lead pin 7 among drawing 11, and the number 251 shows the welded section of the relay lead pin 7 and the stem pin 9.
[0038]Further, the above-mentioned conductive ring 3 is in the state which carried out prescribed distance alienation of the electron multiplier 100 from the wall of the well-closed container, and is provided with the spring electrode 300 for making it install in the prescribed position of this well-closed container. Therefore, the position in a horizontal well-closed container is prescribed by the spring electrode 300 to the incidence direction L of light. The number 303b shows the welded section of the above-mentioned spring electrode 300 and a ring body among drawing 10.
[0039]Next, the structure of the fine mesh dynode applied to the photo-multiplier concerning this invention is explained using drawing 12 - drawing 16.
[0040]Usually, fine mesh dynode says mesh dynode with the 1000 or more 1 inch (=25.4 (mm)) of these base line per number of the line 50-1 which exists on the base line shown by the arrow C in drawing 12 and drawing 13, 50-2, 50-3, and 50-4. And the shape of the pore of fine mesh dynode may be a hexagon, as were shown in drawing 12 and it was shown to drawing 13 by the rectangle.
[0041]In this specification, fine mesh dynode is distinguished with the void S (%). When line width is set to a and it sets a line pitch to b, $S(\%) =\{(b-a)^2/b^2\} \times 100$ defines this void S.

[0042]If in the case of the fine mesh dynode of #1500 the line pitch b shall be 16.9 micrometers (=25.4 (mm) /1500 (book)), for example, line width shall be 5.56 micrometers, specifically, the void will be about 45%.
[0043]Next, the line width of fine mesh dynode is determined by **** of the electron in a magnetic field. That is, rotating, as shown in drawing 14, the secondary electron emitted from the phi mesh dynode in the high magnetic field follows the orbit 700, and reaches the fine mesh dynode of the next step. However, if the line width of this fine mesh dynode is too thick, the secondary electron emitted as shown in drawing 15 follows the orbit 701, and cannot reach the fine mesh dynode of the next step. If it puts in another way, and line width is too thick, the multiplication factor (the number of the photoelectrons generated in several/photoelectric surface of the secondary electron which reaches an anode) of the photo-multiplier concerned will fall.
[0044]Therefore, it is necessary to take into consideration the maximum turning radius of the electron in a magnetic field for the determination of the line width of fine mesh dynode. Concretely, in this example, the following calculations determined the optimal line width.
[0045]That is, the peak value of the energy distribution of a secondary electron is estimated at about 2 (eV) - 3 (eV) (this example shows average value 2.5 (eV) as initial velocity Vphi of a secondary electron). To a magnetic field, in the turning radius R of this electron, an electronic discharge angle becomes the maximum, when perpendicular. Then, magnetic flux density (B):2 (T) of a magnetic field
An electronic discharge angle (theta): Initial velocity of a 90-degree electron (Vphi) :2.5 (eV)
Electronic speed (V):(2-eV phi/m) $^{(1/2)}$ mass of electrons (m):9.1095x10 $^{-31}$ electronic charge When it is considered as (e):1.6022x10 $^{-19}$, the electronic maximum turning radius R can be determined as follows.
[0046]
R=((mV)/(eB)) xsintheta=2.6659x10 $^{-6}$ (m)
**2.7 (micrometer)
The maximum diameter of rotational movement of the electron at this time is about 5.4 (micrometer). moreover -- each electron in which initial velocity differs for reference -- each magnetic flux density (T) -- each time -- the result of having calculated change of the maximum turning radius is shown in drawing 16.
[0047]As for the line width of the fine mesh dynode 50 concerned, it is preferred to set below to at least six (micrometer) so that the above thing may also show. On the other hand, in order to give the intensity which can be borne enough to the tension applied during manufacture at this fine mesh dynode, it is necessary to set the line width as not less than 2.4 micrometers.
[0048]Next, each process is explained one by one about the manufacturing method of above-mentioned fine mesh dynode using drawing 17 - drawing 26.
[0049]First, in the 1st manufacturing process, the slots 121 and 122 of the shape of a lattice type of the fine mesh dynode which it is going to manufacture, and the same shape are minced on the surface of the glass plate 120, and let this be master glass. And it is made to dry after carrying out aqua regia washing of this master glass plate 120 (refer to drawing 17).
[0050]Then, the metal (for example, palladium, silver, platinum, etc.) which becomes a

core wire is made to adhere to this master glass plate 120 surface by a cathode-rays sputtering technique in the 2nd manufacturing process. Then, it leaves the metal 123 used as the core wire included in the slots 121 and 122 of the master glass plate 120 surface, and the other excessive metal is shaved off (refer to drawing 18). By the 3rd manufacturing process, this master glass plate 120 and copper plate electrode which left the above-mentioned core wire 123 are made to counter the slots 121 and 122, it soaks during a coppering bath, and voltage is applied and energized among both. This plates the copper film 124 to the core wire 123 included in the slots 121 and 122 of the master glass plate 120 surface.

[0051]Then, the master glass plate 120 which passed through the above the 1st - 3rd manufacturing process is washed in cold water, it exfoliates and the core wire 123 with which the copper film 124 was plated from this master glass plate 120 surface is dried (the 4th manufacturing process). Thereby, the mesh sheet 50A as shown in drawing 19 is obtained. Drawing 20 and drawing 21 are photographs which show the edge part of the mesh sheet 50A after the 4th manufacturing process (after coppering). In this mesh surface, although wrinkles are looked at by the whole with the plated copper, these wrinkles disappear by heat-treatment mentioned later.

[0052]Artificers got the fine mesh sheet 50A whose sectional shape of the line which forms a lattice the shape of the pore is an approximately square and is approximately elliptical by carrying out the above process one by one. The line width of this fine mesh sheet 50A was 5.5 micrometers, the line pitch was 17 micrometers, and the void was about 45%. Artificers were able to get the fine mesh of #1500, #2000, #2500, and #3000 about the void of 45%, and 50% of each. The line width of each fine mesh is shown below.

[0053]# 1500:5.6 mum (45% of void), 4.98 micrometers (50% of void)
2000:4.18 micrometers (45% of void), 3.72 micrometers (50% of void)
2500:3.34 micrometers (45% of void), 2.97 micrometers (50% of void)
3000:2.79 micrometers (45% of void), 2.48 micrometers (50% of void)
Next, in the 5th manufacturing process, a circular pattern is cut out from the fine mesh sheet 50A manufactured by the above process, and the fine mesh dynode 50 is obtained (refer to drawing 19). since this fine mesh dynode 50 did not have intensity sufficient in itself, it was shown in the 6th manufacturing process of drawing 22 -- as -- this fine mesh dynode 50 -- the 1st page is put with the upper electrode 51 and the lower electrode 52 from thea [50], and 2nd pageb [50] side. In this process, the above-mentioned upper electrode 51 and the lower electrode 52 are piled up so that the breakthroughs 51a and 52a which each has may be in agreement. In order to impress prescribed voltage to the fine mesh NIDAI node 50, the relay lead pin 7 electrically connected with the stem pin 9 equips the upper electrode 51 with the height 51b by which welding immobilization is carried out.

[0054]And so that tension may be uniformly applied to the put fine mesh dynode 50, In the 7th manufacturing process, the dynode part 500 is manufactured by carrying out welding immobilization of the upper electrode 51 and the lower electrode 52 in a prescribed spot, where this fine mesh dynode 50 is put (refer to drawing 23). The number 510 shows the welded place of the upper electrode 51 and the lower electrode 52 among drawing 23. As a material of the above-mentioned upper electrode 51 and the lower electrode 52, there is Nichrome, NM, and stainless steel SUS310S etc.

[0055]However, the deflection of the fine mesh dynode 50 is unremovable only by passing through the above process. Then, once installing the obtained dynode part 500 into the electric furnace of a vacua and heating to 600 ** - 700 **, the deflection of this fine mesh dynode 50 is removed by cooling. Since the alloy of these metallic materials is formed near the interface of the metallic material (Pt) of a core wire, and a plating material (Cu) by heating as a reason a deflection is removed, it is presumed that it originates in the volume change by this alloying.
[0056]In this example, Sb is further vapor-deposited on aluminum which vapor-deposited aluminum (aluminum) on the copper (Cu) plated as a secondary electron emission surface, vapor-deposited antimony (Sb) on this Cu, or was vapor-deposited on Cu. As a reason for vapor-depositing above-mentioned metal on Cu, it is for solving the problem of stability (drift). Vacuum evaporation of aluminum and/or Sb is performed to the photo cathode side of the fine mesh dynode 50.
[0057]As mentioned above, it is heat-treated and the photograph of the fine mesh dynode 50 with which aluminum was further vapor-deposited as a secondary electron emission surface is shown in drawing 24. Drawing 25 is a photograph which shows the fine mesh dynode 50 obtained whole, and drawing 26 is the photograph which photoed the fine mesh dynode 50 shown in the photograph of drawing 25 from the angle leaned 45 degrees.
[0058]Next, the result of having asked for the multiplication factor of the photo-multiplier to the void of the fine mesh dynode 50 concerned by an experiment and simulation computation about each of the number of stages of the fine mesh dynode 50 manufactured as mentioned above, interstage distance, and magnetic field strength is shown below.
[0059]Drawing 27 is a graph which shows the relation of the multiplication factor of the photo-multiplier concerning this invention to the void of the fine mesh dynode 50. This graph shows the theoretical value and actual measurement of a multiplication factor for every line width about each sample (line width is 4 micrometers, 5 micrometers, and 6 micrometers) which has a different void as line width regularity and a line pitch variable.
[0060]When there was no magnetic field (B= 0 (T)), in the range of 53% - 60% of a void, the multiplication factor became more than 1×10^{7}, and was 100 or more times compared with multiplication factor 1×10^{5} in near 40% of a void.
[0061]When the magnetic flux density of a magnetic field was 2T, the fine mesh dynode whose line width is 4 micrometers was 100 or more times of a multiplication factor [in / in the multiplication factor in the range of 55 to 62% of a void / near 40% of a void]. 5-micrometer fine mesh dynode was about 100 times the multiplication factor [in / in the multiplication factor in near 60% of a void / near 40% of a void]. 6-micrometer fine mesh dynode was 100 or more times of a multiplication factor [in / in the multiplication factor in the range of 62 to 70% of a void / near 40% of a void].
[0062]Drawing 28 is a graph which shows the relation of the multiplication factor of the photo-multiplier concerning this invention to the void of fine mesh dynode. This graph shows the theoretical value and actual measurement of a multiplication factor at the time of changing the magnetic flux density in a magnetic field (B= 0 (T) and 2 (T)) about each sample which has a different void as line pitch regularity and a line width variable.
[0063]When there is no magnetic field according to simulation computation (B= 0 (T)), The multiplication factor in near 55% of a void was about 100 times the multiplication

factor in near 35% of a void, and the same multiplication factor was obtained in 45% of the void, and the experimental result and the simulation computation result showed the same tendency. When the magnetic flux density of a magnetic field is 2T, the multiplication factor in near 60% of a void is about 10 times the multiplication factor in near 40% of a void.

[0064]Drawing 29 is a graph which shows the relation of the multiplication factor of the photo-multiplier concerning this invention to the void of fine mesh dynode. This graph shows the theoretical value and actual measurement of a multiplication factor at the time of changing the number of stages (number of stages of dynode) of an electron multiplier (in the case of 16 steps, 19 steps, and 24 steps) about each sample which has a different void as line pitch regularity and a line width variable.

[0065]According to simulation computation, in any case, in near 55% of a void, a multiplication factor shows the maximum, and being about 100 times the multiplication factor in near 35% of a void is admitted. The same multiplication factor was obtained in 45% of the void, and the experimental result and the simulation computation result showed the same tendency.

[0066]In order that artificers might get the desirable multiplication factor of the photo-multiplier concerned from the above experimental result, the conclusion which makes the void of fine mesh dynode appropriate [setting it as 45% - 65% of range] was obtained. However, since the fine mesh dynode 50 is manufactured as mentioned above, considerable intensity is required of this fine mesh dynode 50. It is most preferred that these viewpoints set the void of this fine mesh dynode 50 as 45% - 50% of range.

[0067]. Artificers got about the fine mesh dynode which set the line pitch constant and changed the void by making line width variable. The interval of adjoining fine mesh dynode attached and calculated the simulation result (theoretical value) and actual measurement of the multiplication factor of the photo-multiplier concerned, 0.4 mm, 0.8 mm, and when it was each 1.6 mm. Also in this case, the multiplication factor became the maximum with 45 to 65% of the void similarly.

[0068]The same effect was acquired, also when the pore position had been arranged and arranged in each stage of fine mesh dynode, and also when it had arranged randomly.

[0069]As for the multiplication factor of a photo-multiplier, in the interval between the number of stages of fine mesh dynode, and dynode, and each case of magnetic field strength, the void of fine mesh dynode serves as the maximum in 45% - 65% putting the above various experiments and a simulation computation result together. Especially the void of fine mesh dynode was understood that it is preferred to set it as 45% - 50% of range from a manufacturing viewpoint.

[0070]This invention is not limited to the example mentioned above, and various modification is possible for it. For example, the shape of the pore of the pore shape of fine mesh dynode may be a rectangle, a hexagon, or other polygons. As shown in drawing 13, specifically, the fine mesh dynode which has the pore shape of a hexagon may be sufficient, for example. This fine mesh dynode has the shape where the pore of the hexagon was located in a line in the shape of [of the bee] a nest. The pore shape of this fine mesh dynode may be aperiodic shape, and the pore of different shape may be arranged.

[0071]

[Effect of the Invention]As mentioned above, according to this invention, the hollow pipe

which penetrated each electrode which supports fine mesh dynode prescribes the laminated structure of an electron multiplier. The photo-multiplier which controlled the interval between each fine mesh dynode correctly and with which the manufacture error was controlled by this is obtained. A possibility that variation will arise in a multiplication factor or fine mesh dynode will be torn during manufacture by this is reduced remarkably. Since a part of this hollow pipe comprises a conductive material, it can function also as a part of supply structure of the voltage impressed in order to set photo cathode as prescribed potential.

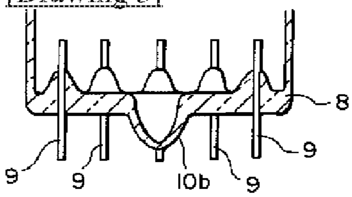
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a figure showing the assembly process of the whole photo-multiplier concerning this invention.
[Drawing 2]It is a perspective view showing the structure after an assembly of the photo-multiplier shown in drawing 1.
[Drawing 3]It is a stem portion in the **2**(ed) photo-multiplier, and is a sectional view showing the structure of this stem portion after photo cathode formation.
[Drawing 4]It is a figure showing the structure of an electron multiplier of the photo-multiplier shown in drawing 2.
[Drawing 5]It is a figure expanding and showing the structure of the portion shown by A in drawing 4.
[Drawing 6]It is a figure showing the structure of the pipe for laminating each fine mesh dynode for every prescribed interval, and constituting an electron multiplier (the 1).
[Drawing 7]It is a figure showing the structure of the pipe for laminating each fine mesh dynode for every prescribed interval, and constituting an electron multiplier (the 2).
[Drawing 8]It is a figure expanding and showing the internal structure of the portion shown by B in drawing 4.
[Drawing 9]It is a figure showing the composition of the bleed-screw circuit for setting each of photo cathode, each dynode, and an anode as prescribed potential.
[Drawing 10]It is a top view showing the detailed structure of the ring for installing an electron multiplier in the prescribed position in a well-closed container.
[Drawing 11]It is a sectional view of a photo-multiplier for explaining the wiring structure for setting photo cathode as prescribed potential.
[Drawing 12]It is a perspective view showing the composition of the 1st example of fine mesh dynode.
[Drawing 13]It is a perspective view showing the composition of the 2nd example of fine mesh dynode.
[Drawing 14]It is a figure for explaining the relation between **** of the electron in a high magnetic field, and the line width of the fine mesh dynode shown in drawing 12 and drawing 13 (the 1).
[Drawing 15]It is a figure for explaining the relation between **** of the electron in a high magnetic field, and the line width of the fine mesh dynode shown in drawing 12 and drawing 13 (the 2).
[Drawing 16]It is a graph which shows a relation (theoretical value) with the maximum turning radius of the electron to magnetic field strength.

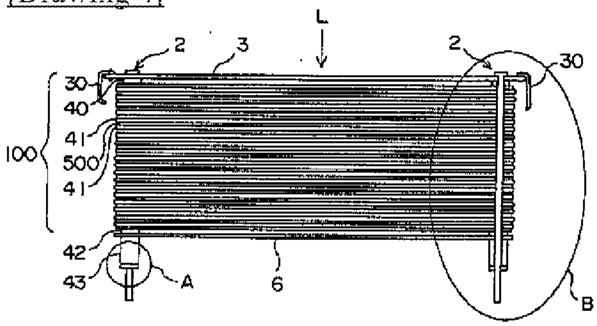
[Drawing 17]It is a figure showing the 1st manufacturing process for explaining the manufacturing method of fine mesh dynode.
[Drawing 18]It is a figure showing the 2nd manufacturing process for explaining the manufacturing method of fine mesh dynode.
[Drawing 19]It is a figure showing the 5th manufacturing process for explaining the manufacturing method of fine mesh dynode.
[Drawing 20]It is the SEM photograph which photoed the appearance of this fine mesh after carrying out coppering to the core wire which constitutes fine mesh dynode (the 1).
[Drawing 21]It is the SEM photograph which photoed the appearance of this fine mesh after carrying out coppering to the core wire which constitutes fine mesh dynode (the 2).
[Drawing 22]It is a figure showing the 6th manufacturing process for explaining the manufacturing method of fine mesh dynode.
[Drawing 23]It is a figure showing the 7th manufacturing process for explaining the manufacturing method of fine mesh dynode.
[Drawing 24]It is a SEM photograph which shows the appearance of the fine mesh dynode after passing through the 7th manufacturing process (after heat-treatment and aluminum vacuum evaporation).
[Drawing 25]It is a SEM photograph which shows the whole fine mesh dynode of obtained #2000.
[Drawing 26]It is the SEM photograph which photoed the fine mesh dynode of drawing 25 from the angle of 45 degrees.
[Drawing 27]It is a graph which shows the relation of the multiplication factor of the photo-multiplier concerning this invention to the void of fine mesh dynode. This graph shows the theoretical value and actual measurement of a multiplication factor for every line width about each sample which has a different void as line width regularity and a line pitch variable.
[Drawing 28]It is a graph which shows the relation of the multiplication factor of the photo-multiplier concerning this invention to the void of fine mesh dynode. This graph shows the theoretical value and actual measurement of a multiplication factor at the time of changing the magnetic flux density in a magnetic field about each sample which has a different void as line pitch regularity and a line width variable.
[Drawing 29]It is a graph which shows the relation of the multiplication factor of the photo-multiplier concerning this invention to the void of fine mesh dynode. This graph shows the theoretical value and actual measurement of a multiplication factor at the time of changing the number of stages (number of stages of dynode) of an electron multiplier about each sample which has a different void as line pitch regularity and a line width variable.
[Description of Notations]
1 [-- An anode, 7 / -- Relay lead pin,] -- Housing, 2 -- A pipe, 3 -- A conductive ring, 6 8 -- A stem, 9 -- A lead pin (stem pin), 11 -- Photo cathode, 40, 41, 42, 43, 430, and 431 -- an insulator (a ceramic spacer.) A ceramic ring spacer, 50 -- Fine mesh dynode, 51 [-- An inner pipe, 201 / -- An outside pipe, 202 / -- A T character-like edge part 205 / -- A caulking part, 300 / -- A spilling electrode, 301 / -- A contact electrode, 500 / -- Dynode part.] -- An upper electrode, 52 -- A lower electrode, 100 -- An electron multiplier, 200

DRAWINGS

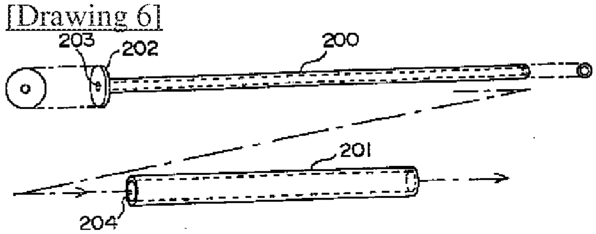
[Drawing 3]



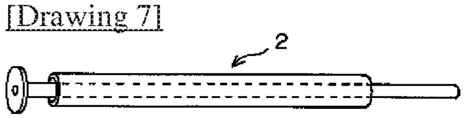
[Drawing 4]



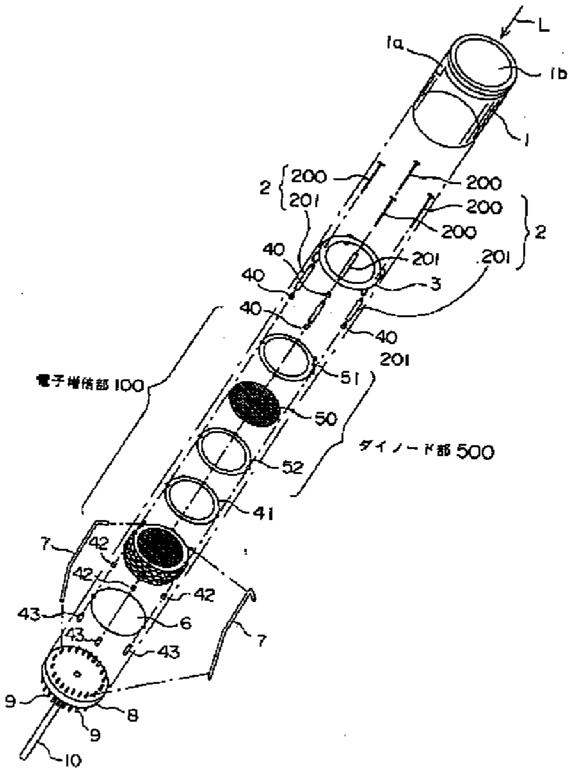
[Drawing 6]



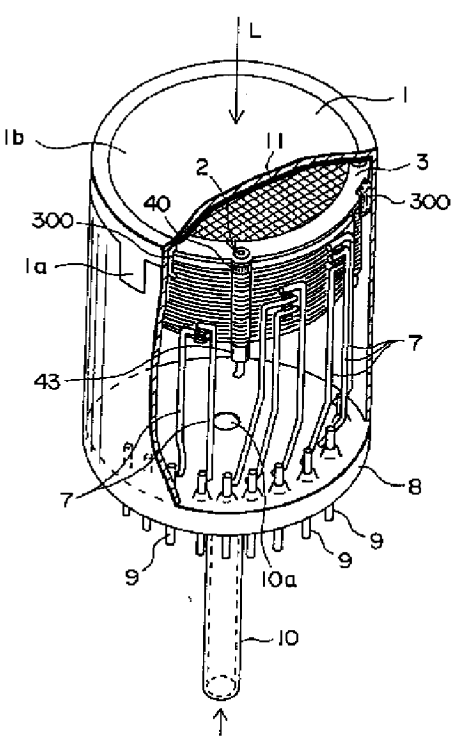
[Drawing 7]



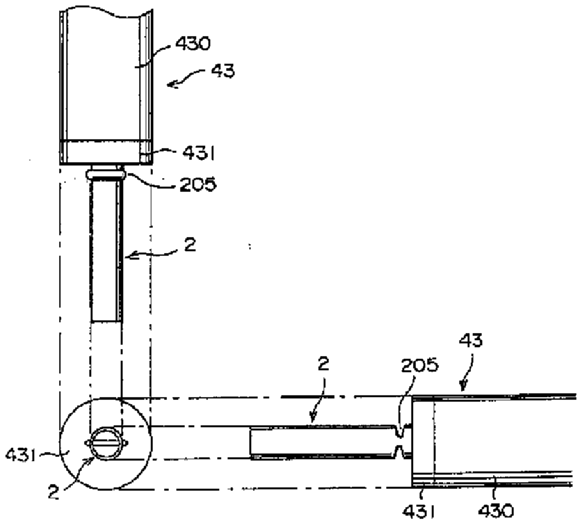
[Drawing 1]



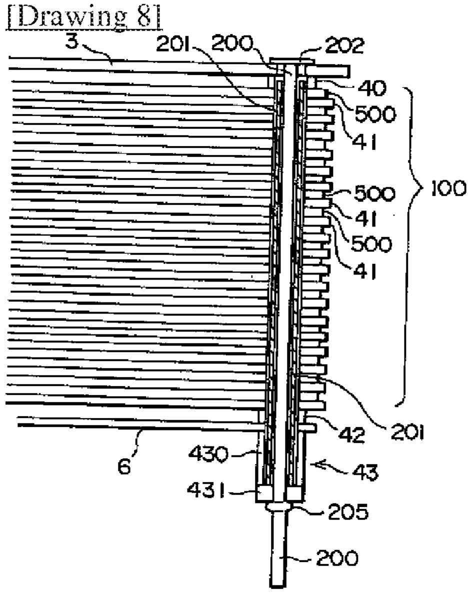
[Drawing 2]



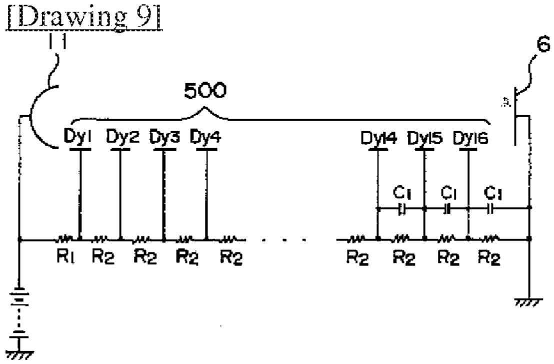
[Drawing 5]



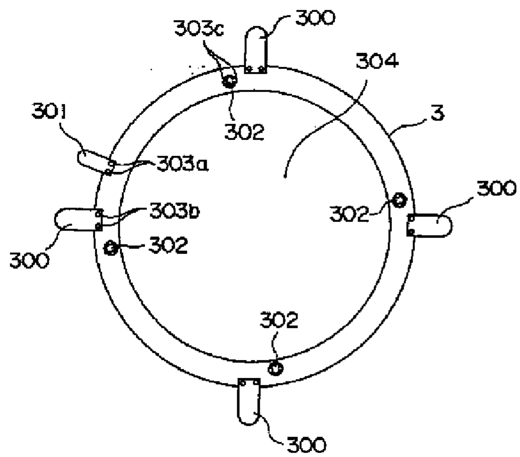
[Drawing 8]



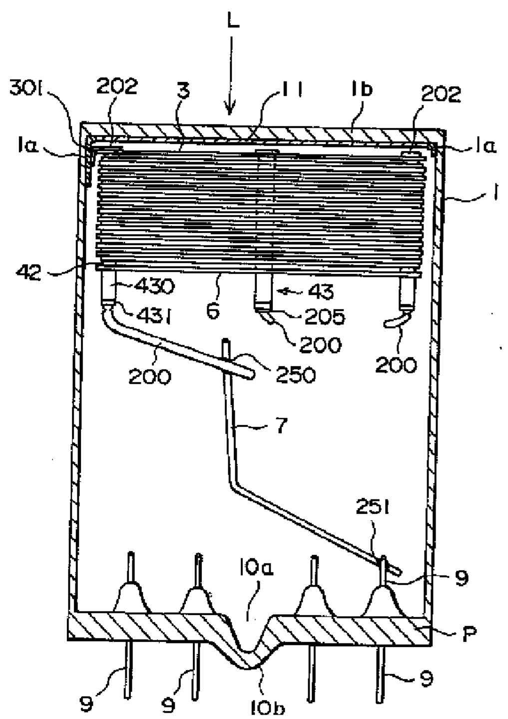
[Drawing 9]

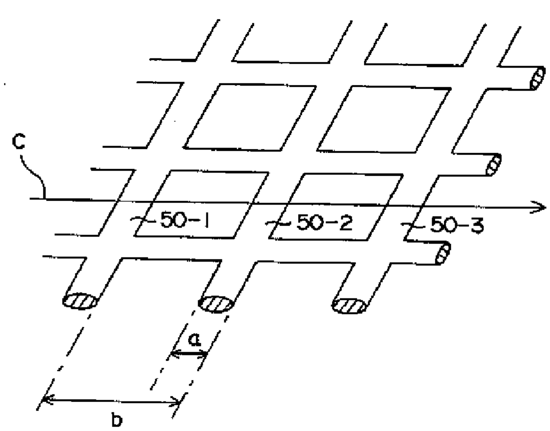


[Drawing 10]



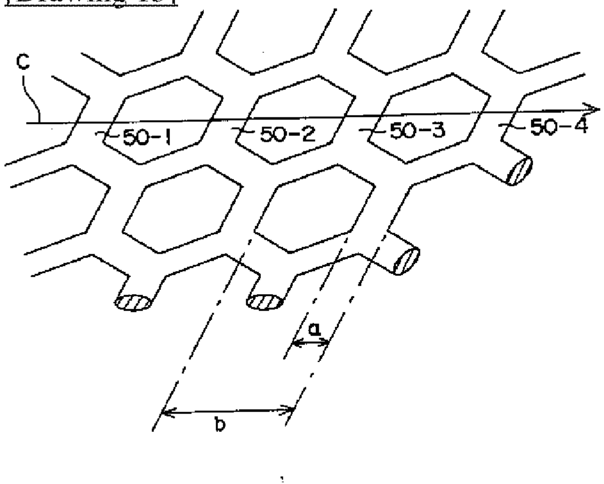
[Drawing 11]



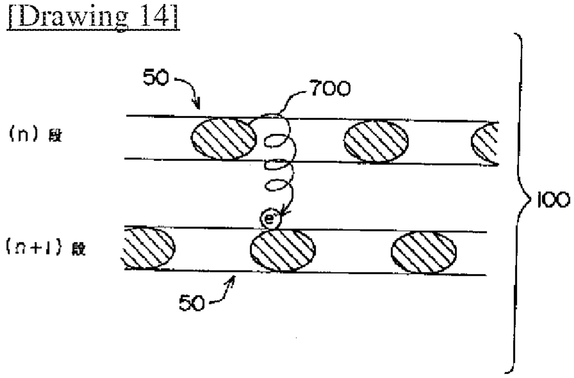


[Drawing 12]

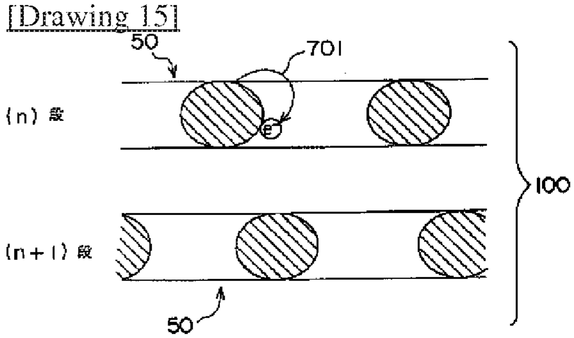
[Drawing 13]



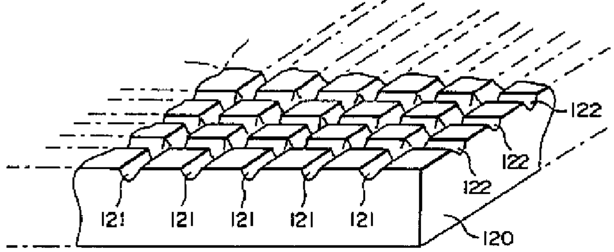
[Drawing 14]



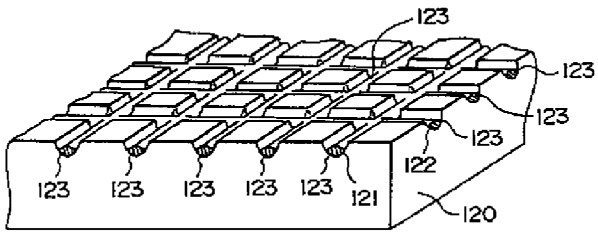
[Drawing 15]



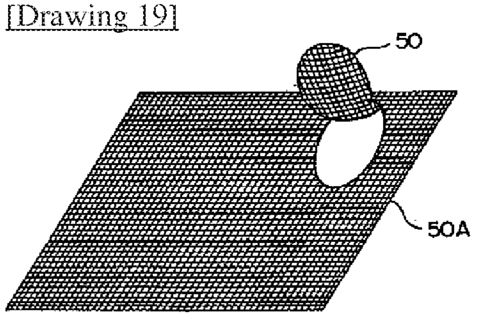
[Drawing 17]



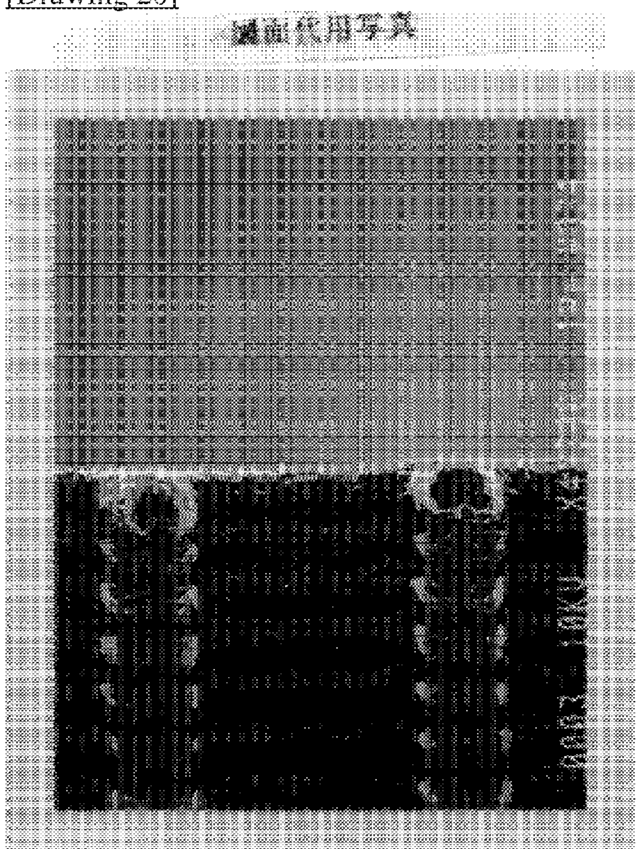
[Drawing 18]



[Drawing 19]

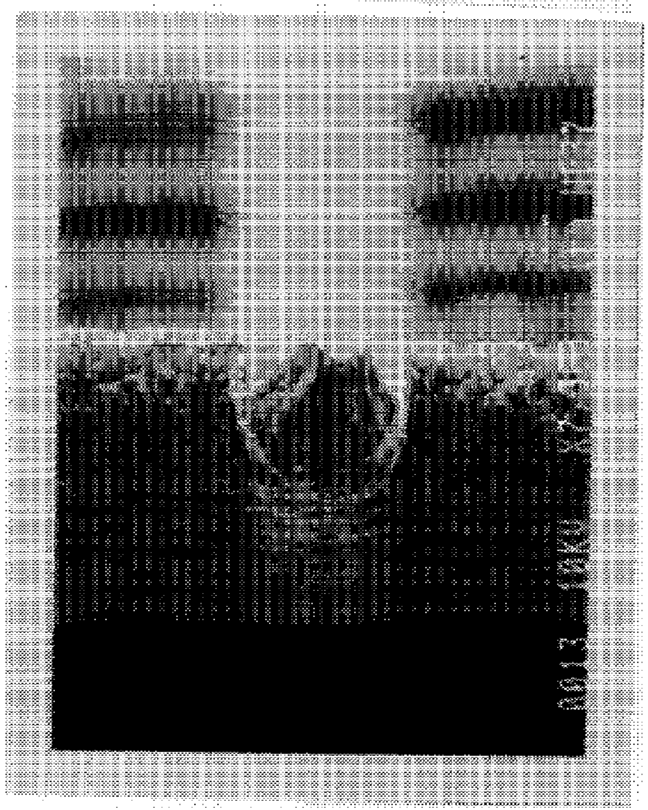


[Drawing 20]

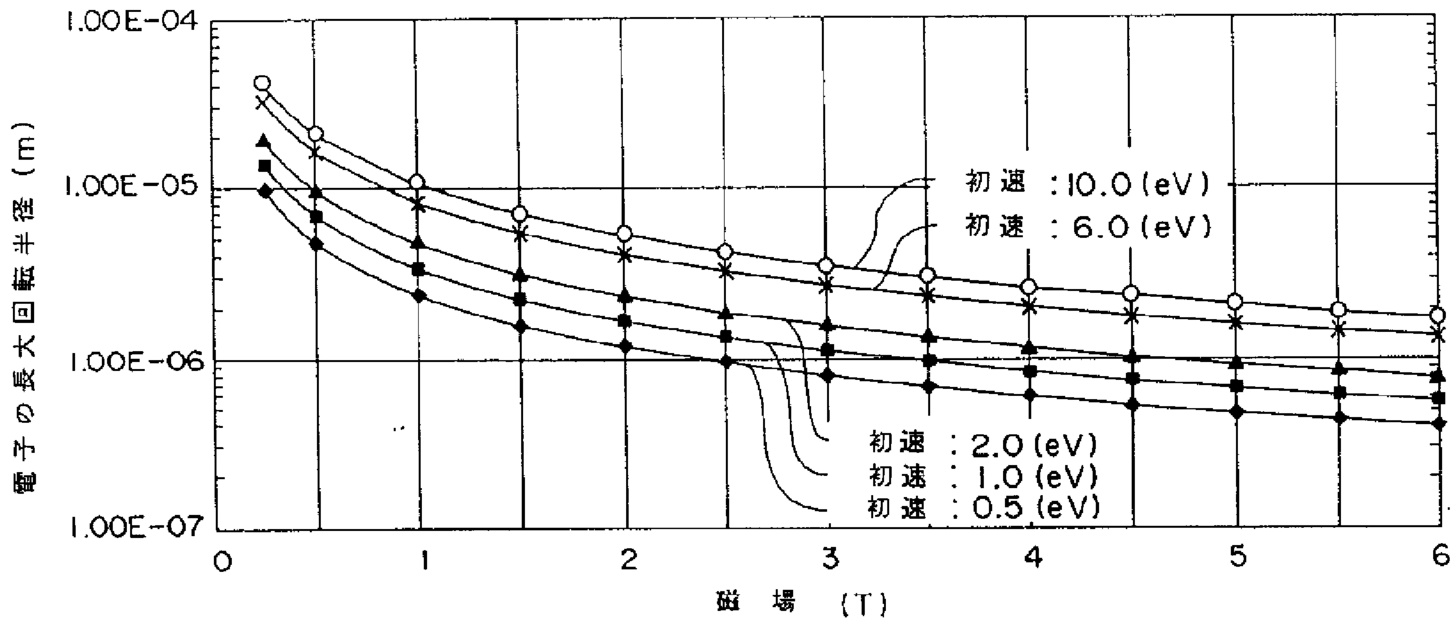


[Drawing 21]

図面代用写真



[Drawing 16]



電子の最大回転半径 $R = \frac{m v}{e B} \cdot \sin\theta$ (m)

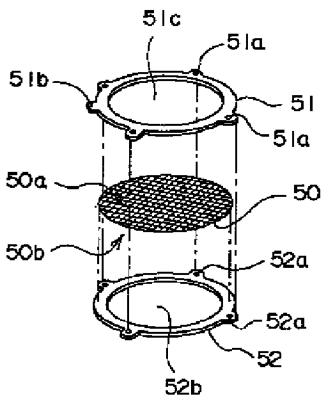
電子の最大回転周期 $T = \frac{2\pi m}{e B}$ (s)

運動中電子の速度 $v = \sqrt{\frac{2 e v_\phi}{m}}$ (m/s)

電子１個あたりの質量 $m = 9.1095 \times 10^{-31}$ (kg)

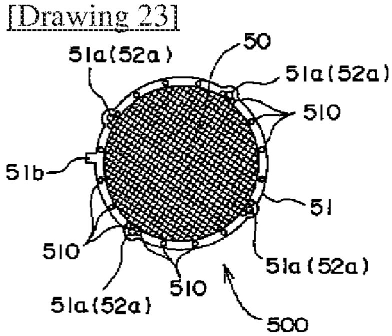
電子１個あたりの電荷 $e = 1.6022 \times 10^{-19}$ (C)

[Drawing 22]



51c
51a
51b
51
51a
50a
50
50b
52a
52a
52
52b

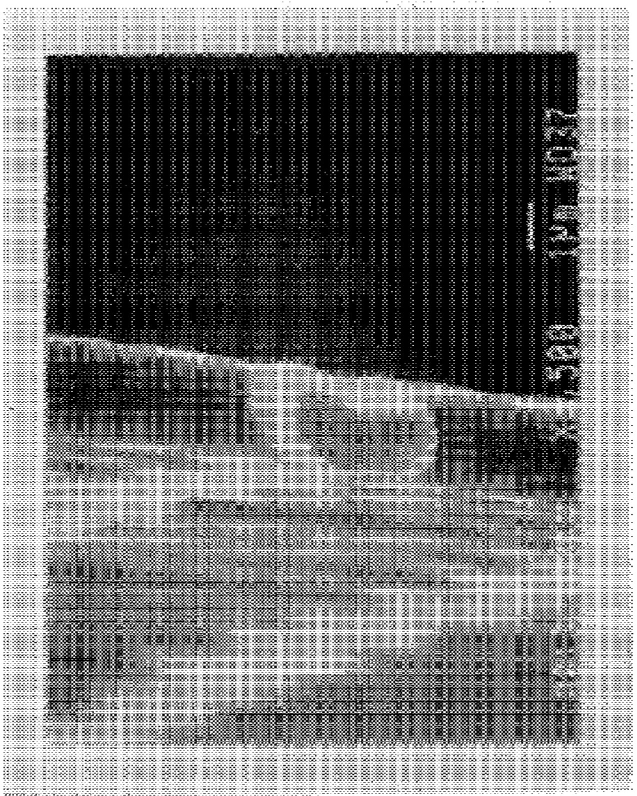
[Drawing 23]



50
51a(52a)
51a(52a)
510
51b
51
510
51a(52a)
510
51a(52a)
500

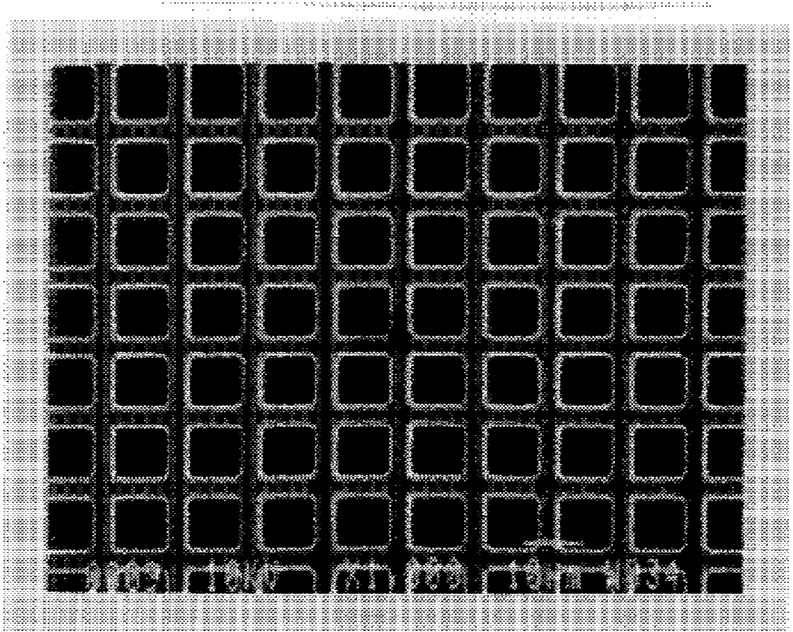
[Drawing 24]

図面代用写真



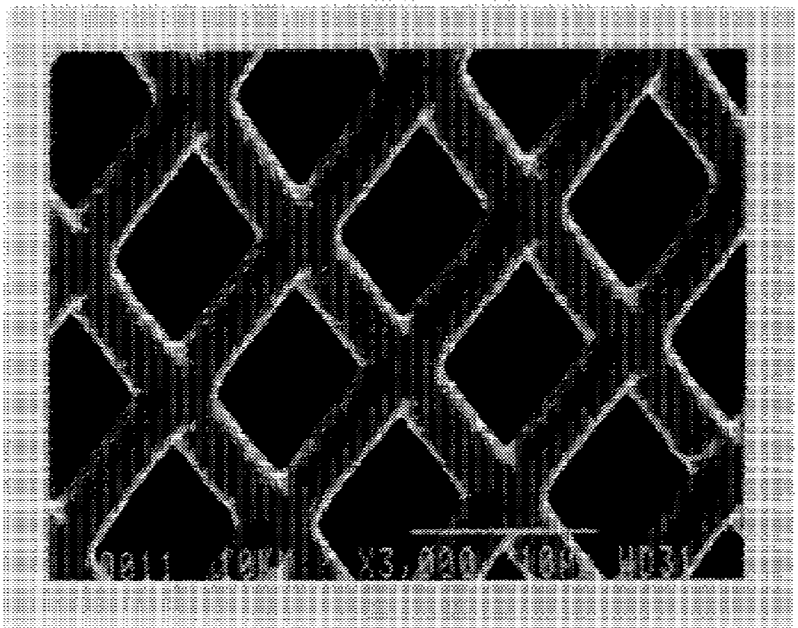
[Drawing 25]

図面代用写真

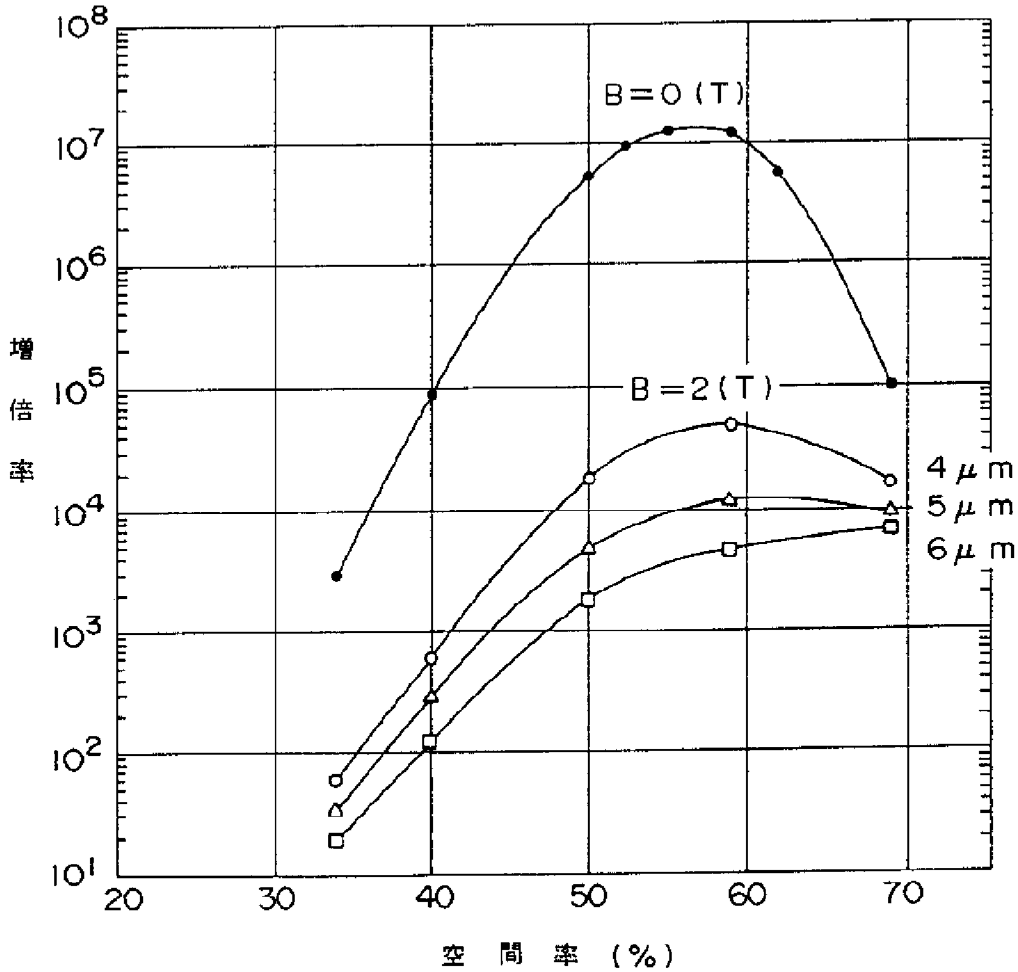


[Drawing 26]

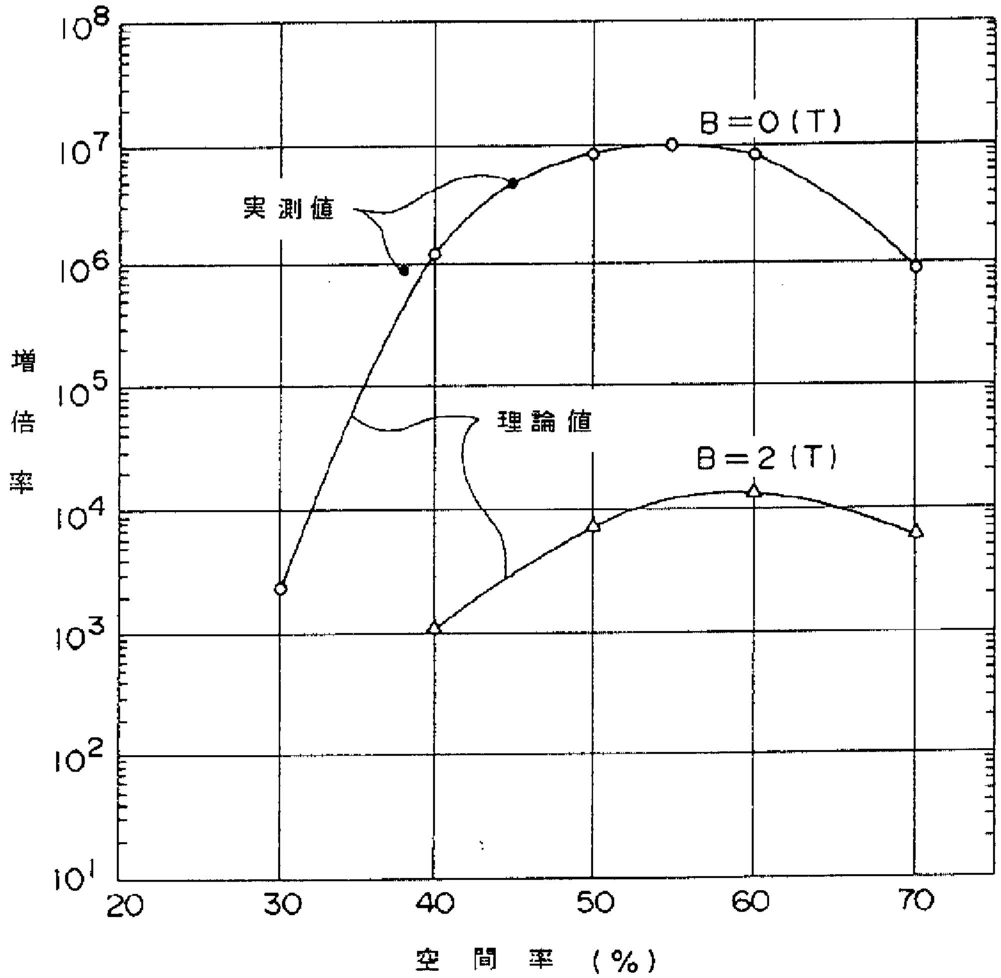
図面代用写真



[Drawing 27]

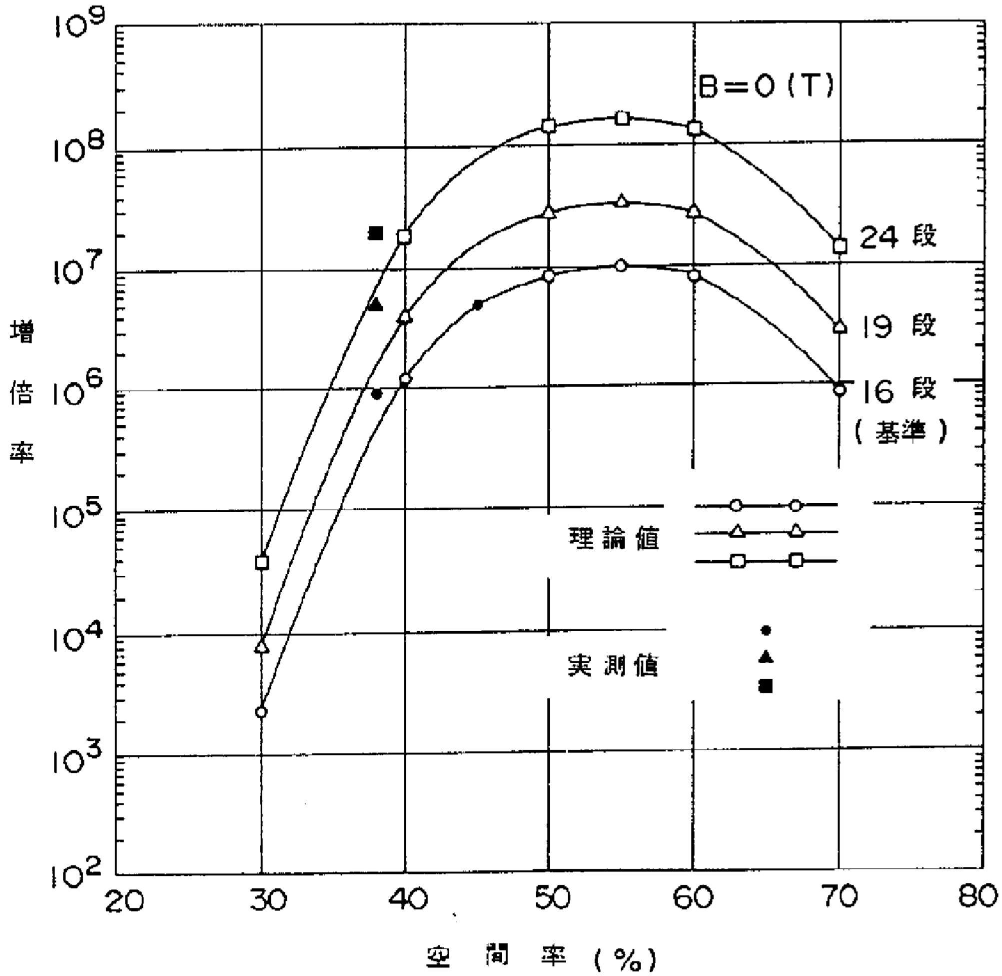


[Drawing 28]



10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
B＝0 (T)
B＝2 (T)
実測値
理論値
増倍率
20
30
40
50
60
70
空 間 率 （%）

[Drawing 29]



B=0 (T)
24 段
19 段
16 段
(基準)
理論値
実測値
増倍率
空間率 (%)
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^2
20
30
40
50
60
70
80